

Piezopumps using no physically moving parts

Zensheu Chang and Yoseph Bar-Cohen, NDEAA Technologies,
Jet Propulsion Laboratory (JPL),
California Institute of Technology (Caltech), Pasadena, CA

Miniature Vacuum Pumps Workshop
July 20-21, 1999

Acknowledgement: The described research was carried out by JPL/Caltech,
under a contract with National Aeronautics and Space Administration (NASA)

Current effort

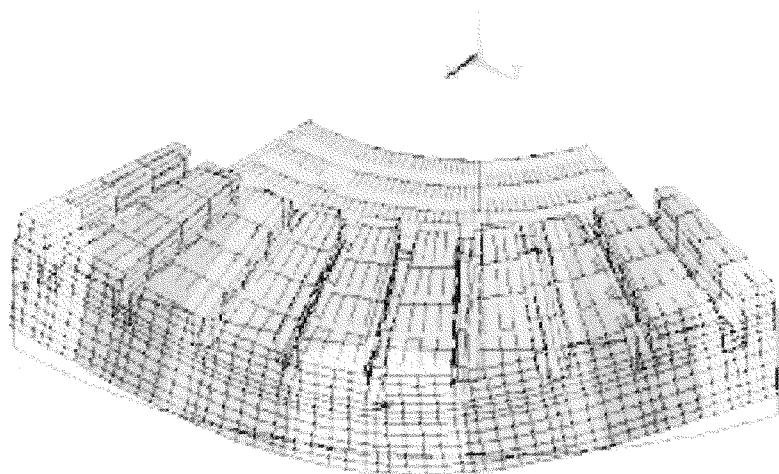
- Design and produce a miniature, low mass, low power-consumption piezoelectrically actuated peristaltic pump.
- Theoretical model the pump to allow interactive design.
- Design and test to meet requirements of a miniature mass spectrometer for *in-situ* sample analysis.
- Test the performance of the pump in simulated planetary conditions.
- demonstration of the capability of the proposed pump.

USM test facility

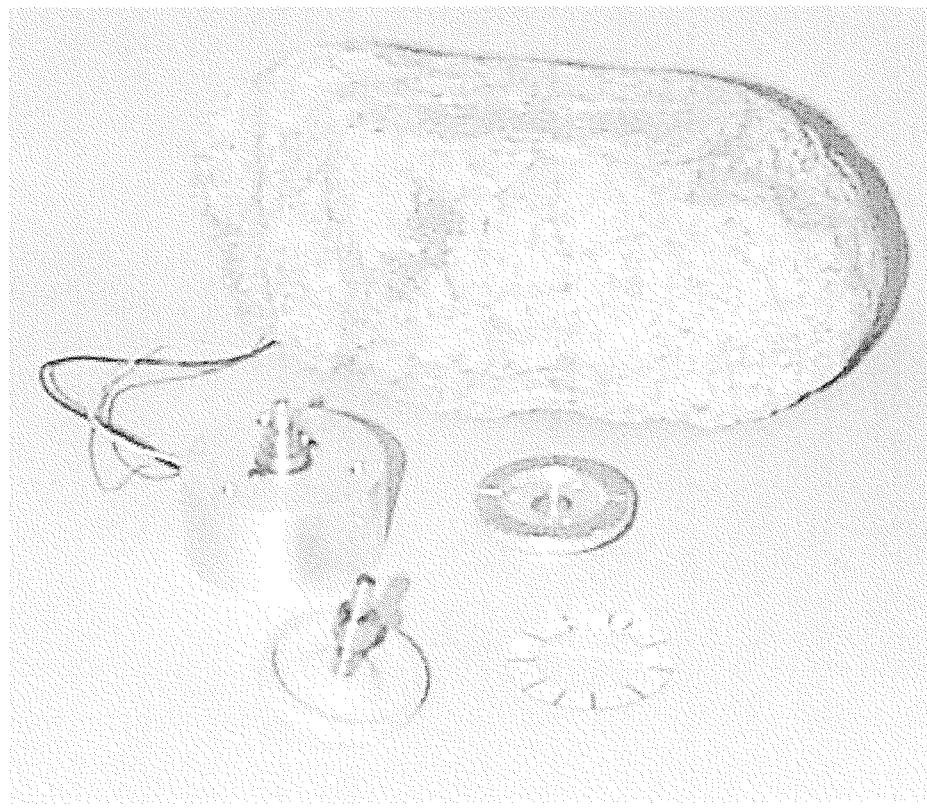


Ultrasonic Motors at JPL

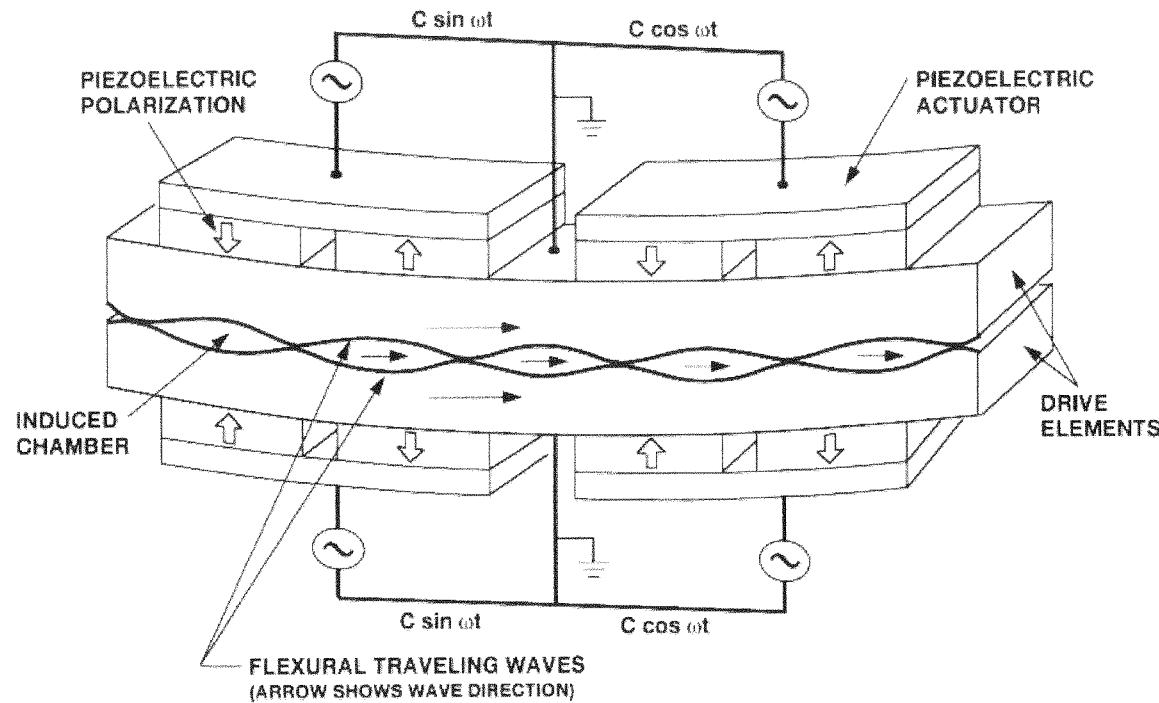
3D FEM



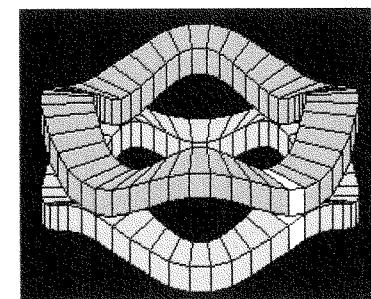
Stator, rotor, piezo-ring and assembled USM



Piezoelectrically Actuated Miniature Pump (PIEZOPUMP)



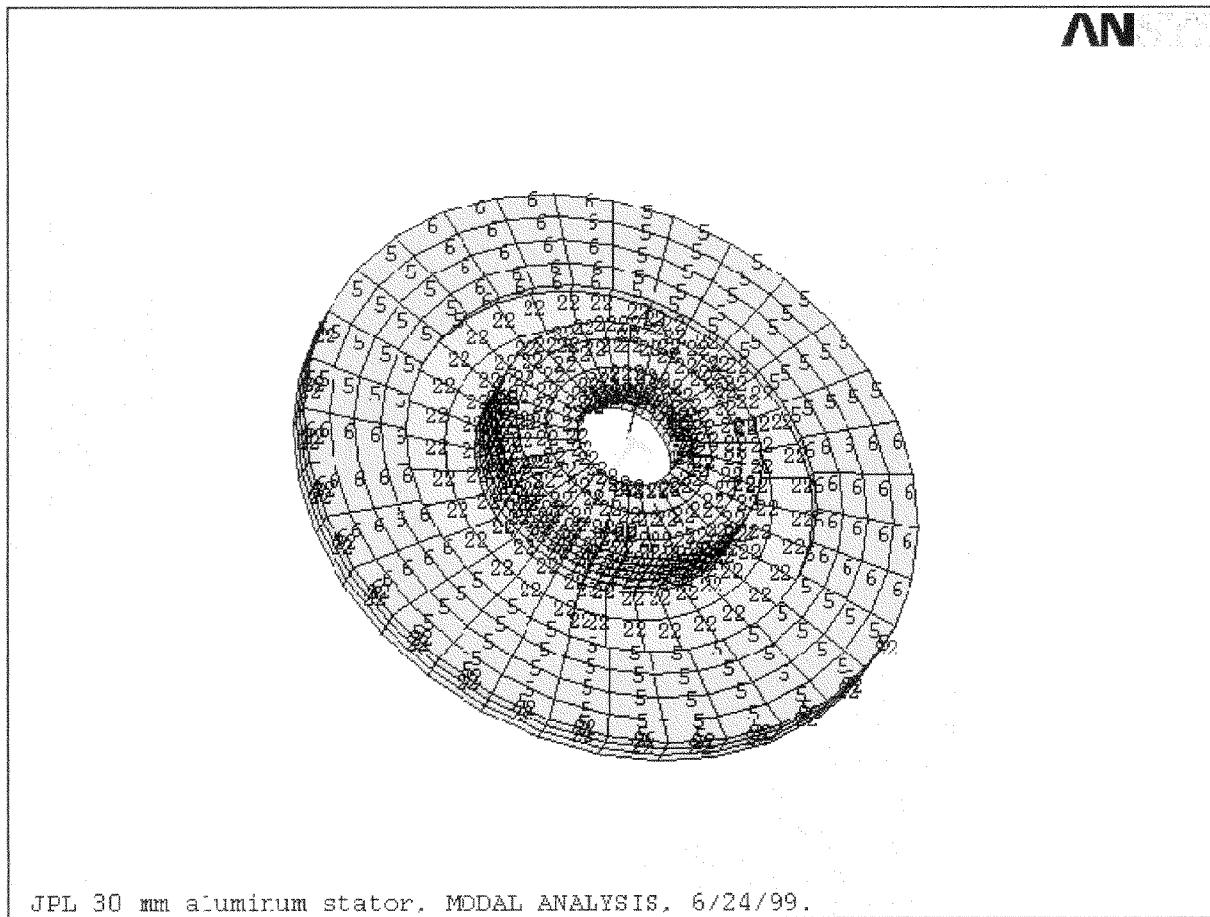
Concept



FEM Modeling

Pump Stator FEM Mesh

For the modal and harmonic analysis of the 3-wave mode



5-wave mode at resonance



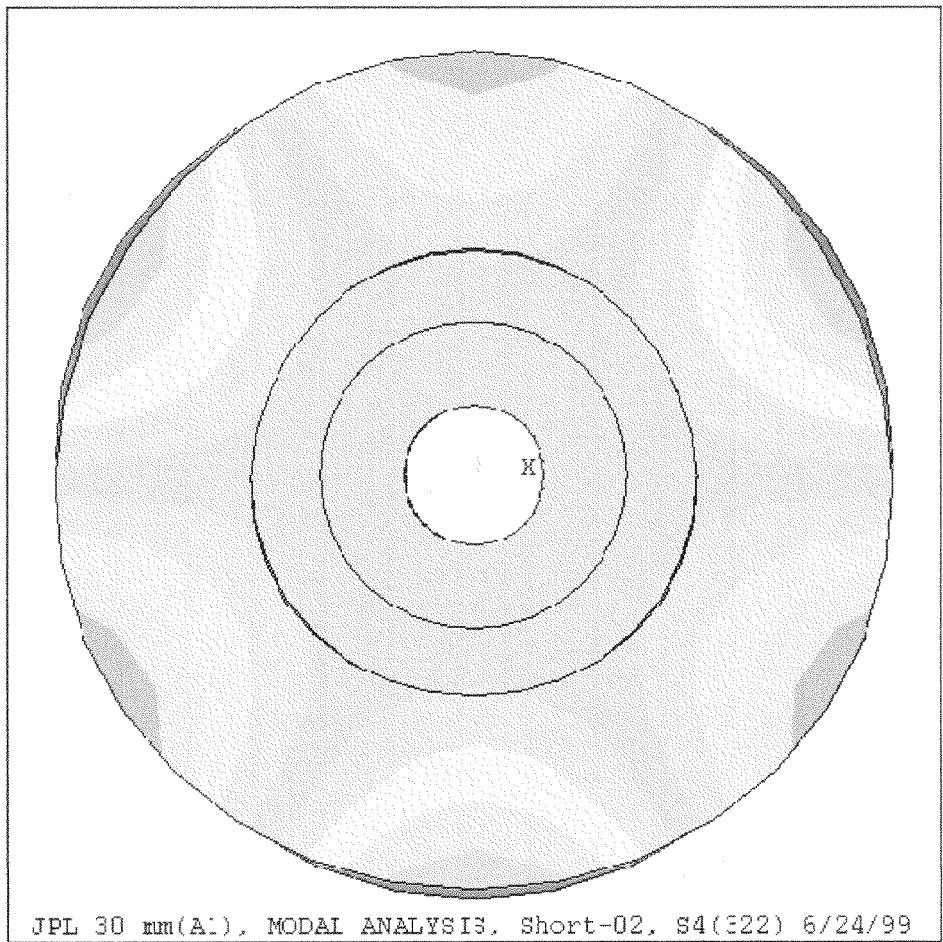
```
ANSYS 5.4
JUL 15 1999
09:16:24
NODAL SOLUTION
STEP=1
SUB =16
FREQ=41706
UZ      (AVG)
RSYS=0
PowerGraphics
EFACET=1
AVRES=Mat
DMX =46.571
SMN =-46.251
SMX =46.255
-46.251
 35.972
-25.694
-15.416
-5.137
 5.141
 15.42
 25.698
 35.977
 46.255
```

4-wave mode at resonance



```
ANSYS 5.4
JUL 15 1999
00:15:48
NODAL SOLUTION
STEP=1
SUB =11
FREQ=26117
UZ           (AVG)
RSYS=0
PowerGraphics
EFACET=1
AVRES=Mat
DMX =43.178
SMN =-42.678
SMK =42.687
-42.678
33.193
-23.708
-14.223
-4.738
4.747
14.232
23.717
33.202
42.687
```

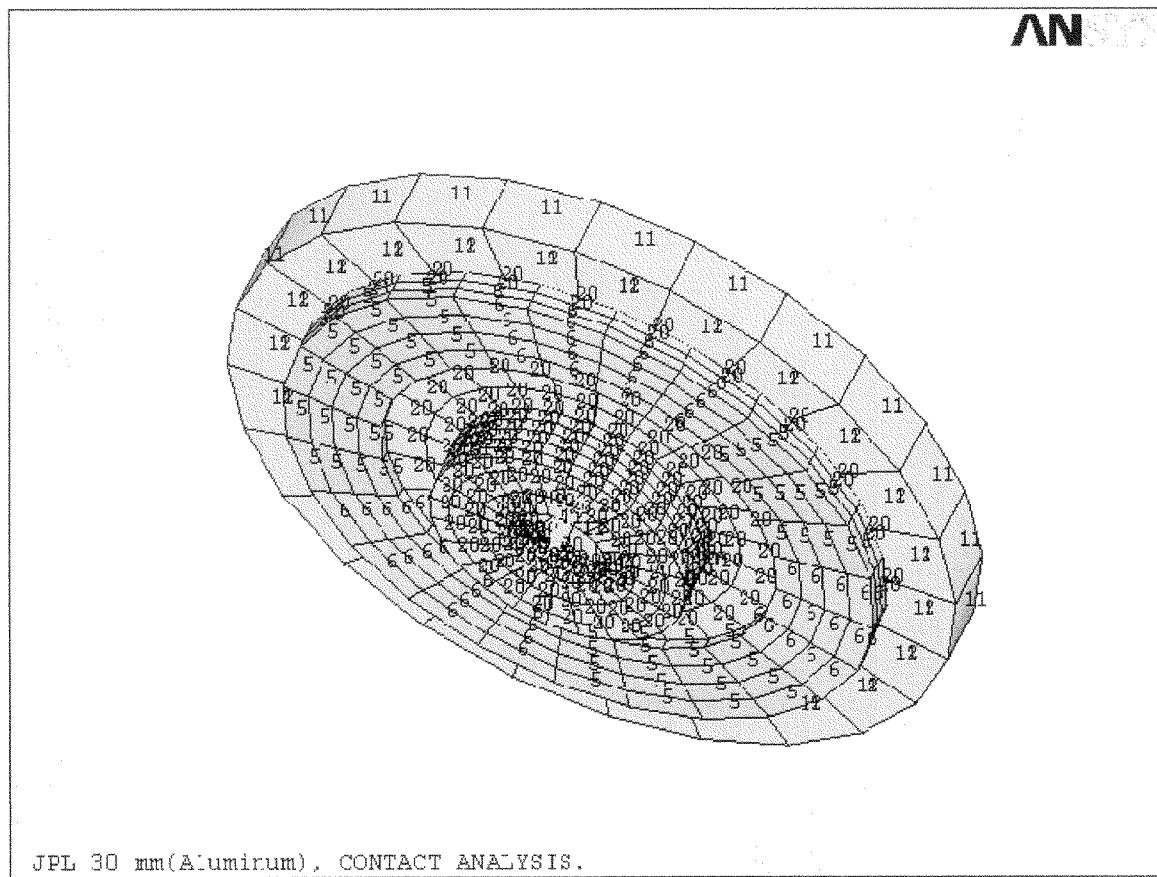
3-wave mode at resonance



ANSYS 5.4
JUL 15 1999
09:14:51
NODAL SOLUTION
STEP=1
SUB =7
FREQ=14406
UZ (AVG)
RSYS=0
PowerGraphics
EFACET=1
AVRES=Mat
DMX =39.843
SMN =-39.666
SMK =39.666
-39.666
30.851
-22.036
-13.222
-4.407
4.407
13.222
22.037
30.851
39.666

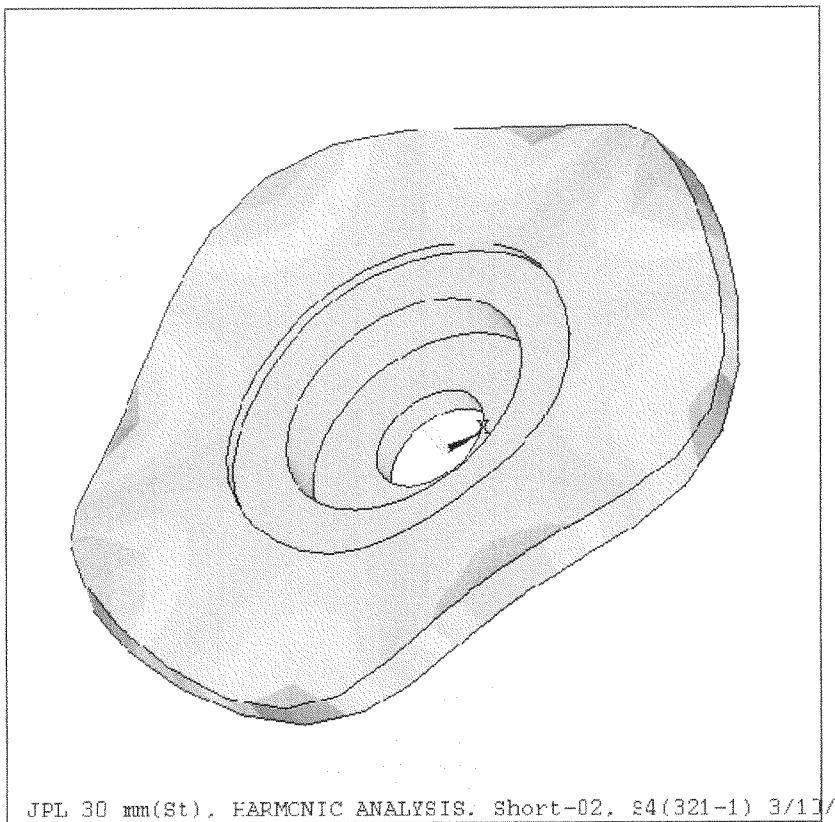
Pump Stator FEM Mesh

For the contact analysis of the 3-wave mode (complete pump)



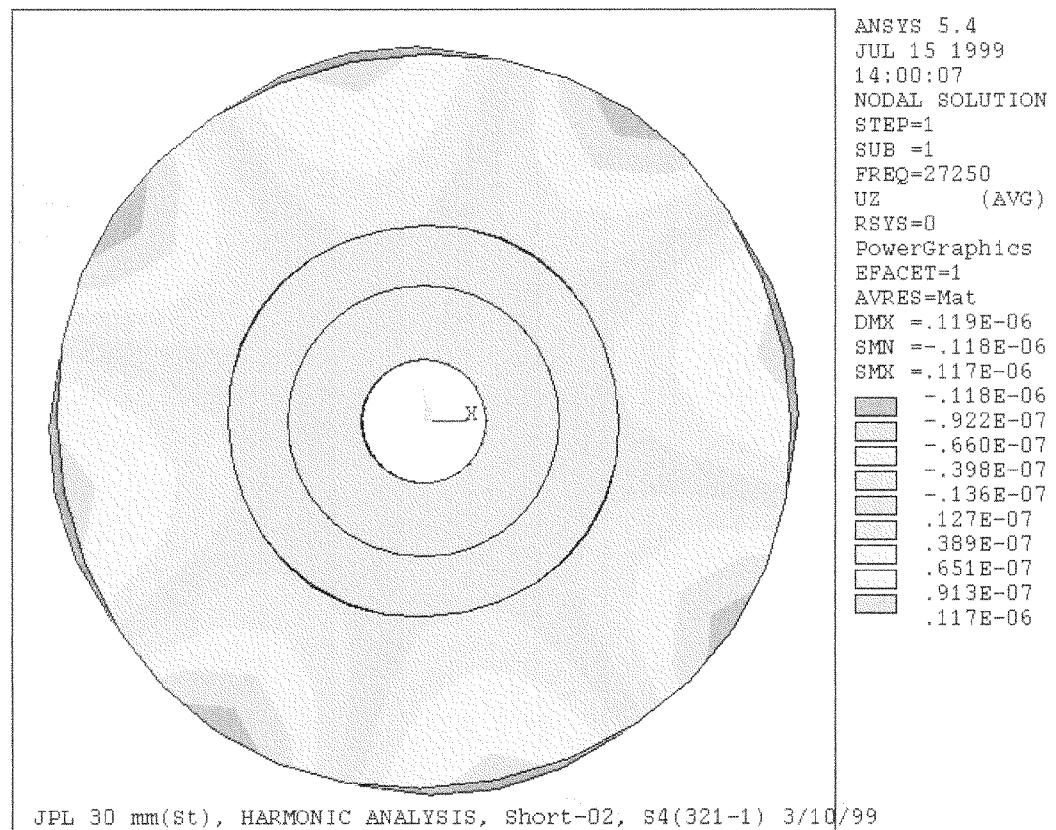
Harmonic analysis of 4-wave steel stator

Side view

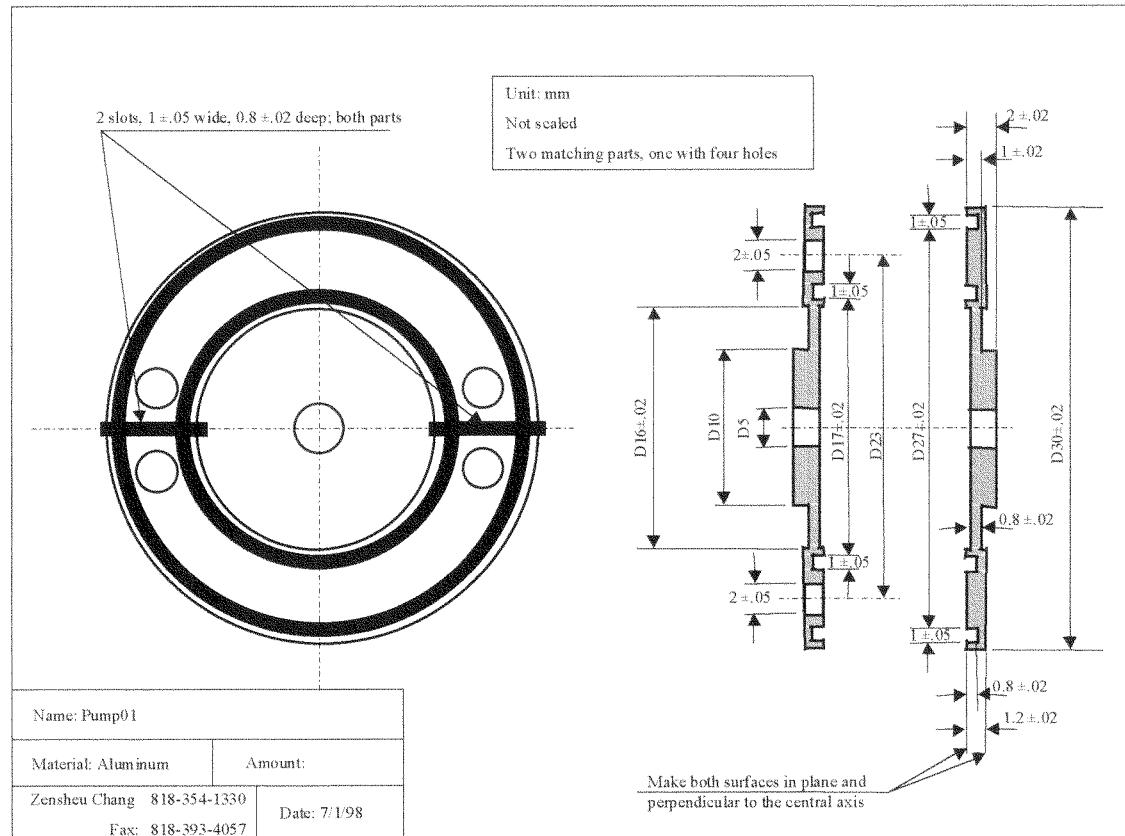
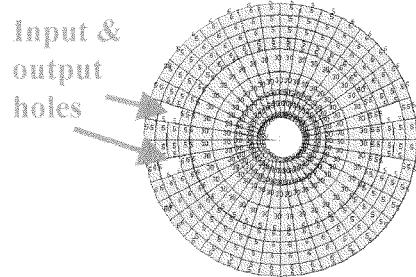


Harmonic analysis of 4-wave steel stator

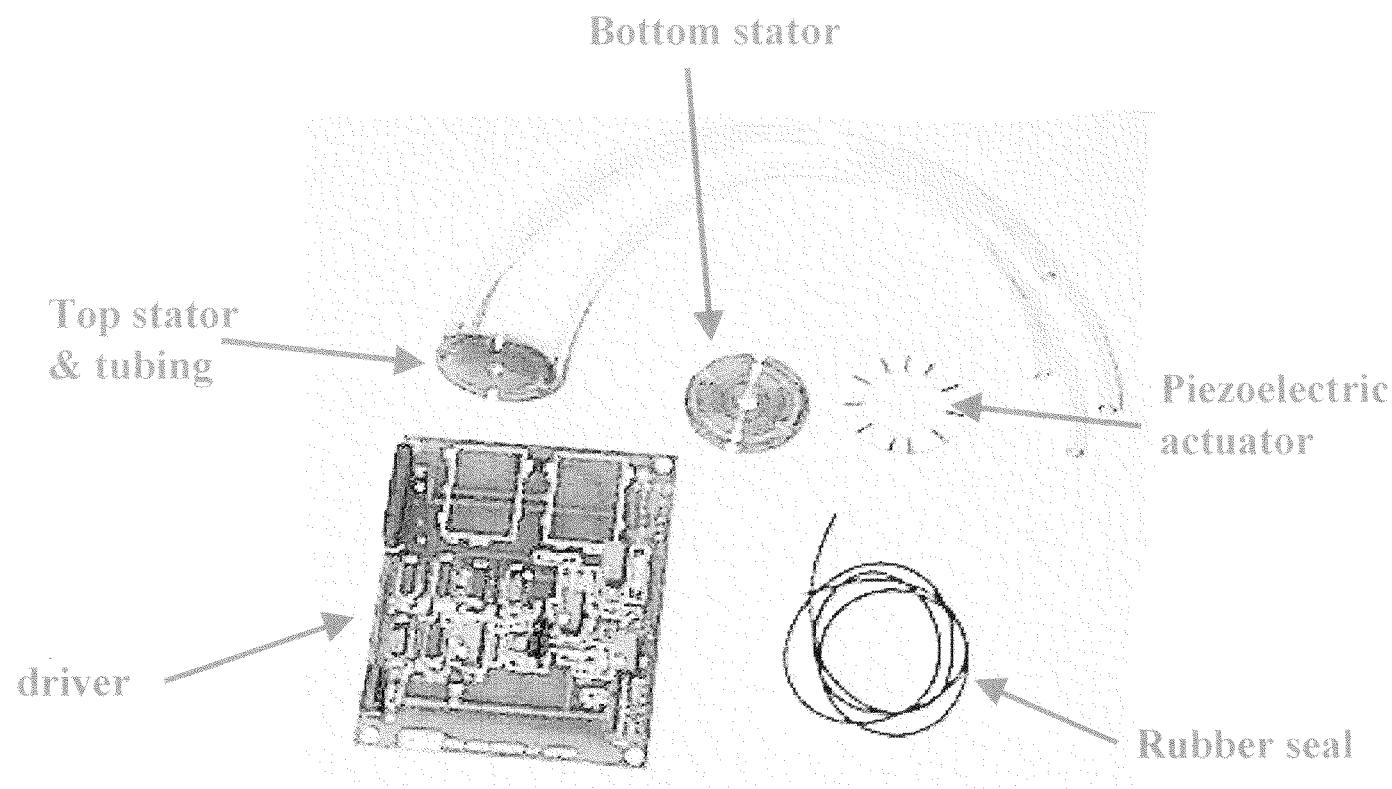
Front view



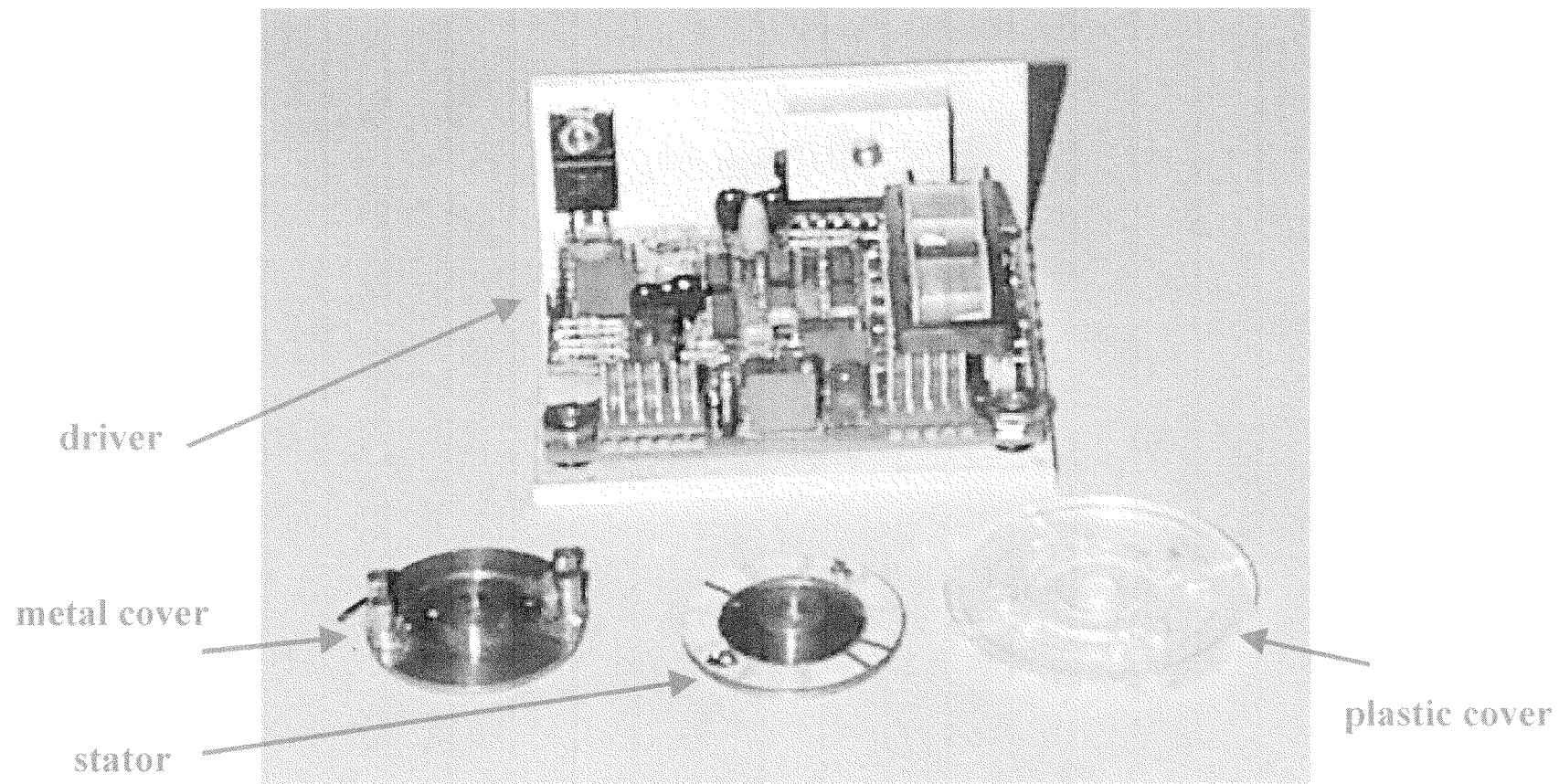
Brassboard design



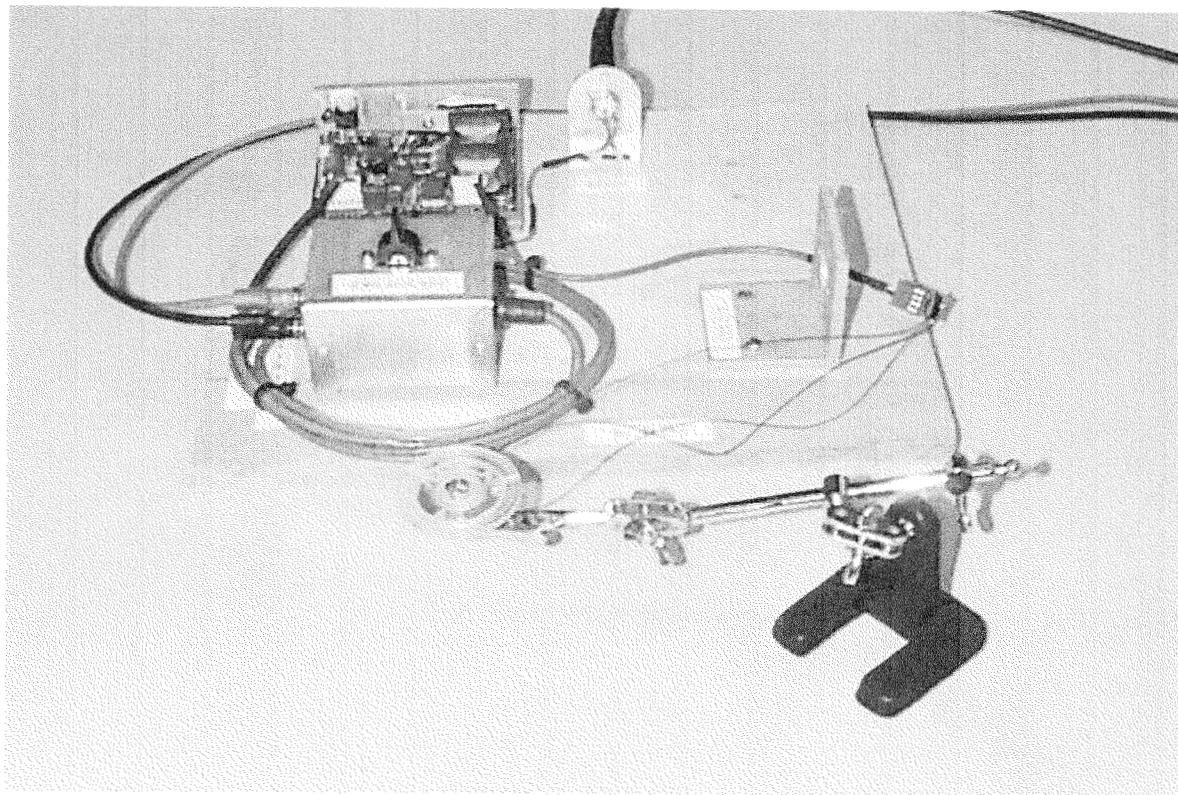
Piezopump Brassboard 1



Piezopump Brassboard 2



Assembled Piezopump



Summary

- A new pumping concept was demonstrated using traveling flexural waves.
- The pump operates peristaltically and easily reversed.
- Analytical modeling addressing the contact problem was developed
- Mode and construction material selection are currently under way to optimize the performance